Electric fields	**Electric fields and capacitance**

Learning objectives	**MUST (C)**	Recall how electric fields are measured and represented
	SHOULD (B)	Derive and apply the equation for electric field strength between parallel plates
	COULD (A/A*)	Recall and apply the equation for capacitance

STARTER: An alpha particle approaches a gold nucleus. It reaches a distance of 4.5×10^{-14} m from the centre of the gold nucleus (proton number 79). Calculate the force between the alpha particle and the gold nucleus.

[redacted]

EXTENSION: How would the acceleration of the alpha particle change as it approached the nucleus?

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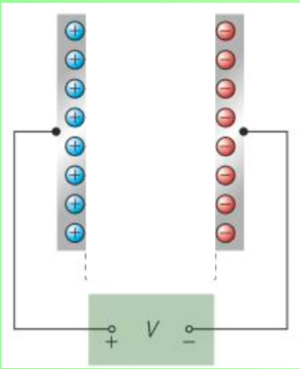

Sketch these two parallel plates with potential difference V. What does the electric field between them look like?

What would happen if there was a +Q charge next to the positive plate? What kind of force would it experience?

The charge gains energy as it moves to the negative plate. The force is constant, given by F = EQ. Using two different ways of expressing work done, we can find an equation to help us find the electric field strength.

Expressions for work done...	
Work done is force x distance moved in the direction of the force	According to the definition of p.d., V = work done per unit charge - V = W/Q
W = Fd We know that for an electric field, E = F/Q and so F = EQ. Substitute EQ for F:	We rearrange this equation for work done:
W = EQd	W = QV

Now equate these two expressions for W:

[redacted]

[redacted]

[redacted]

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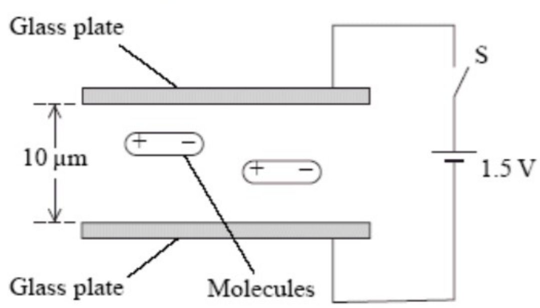
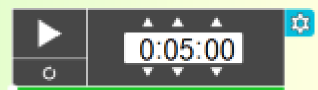
Liquid crystal displays (LCDs) are made from two parallel glass plates, 10 μm apart, with liquid crystal molecules between them. The glass is coated with a conducting material.



Mini-plenary



a) Calculate the electric field strength between the plates when the switch S is closed. (2)

b) Explain what will happen to the liquid crystal molecules. (3)

[redacted]

[redacted]

Electric fields	**Electric fields and capacitance**
COULD (A/A*)	Recall and apply the equation for capacitance

The equation for capacitance for a parallel plate capacitor with a vacuum between the plates is:

$$C = \frac{\varepsilon_0 A}{d}$$

ε_0 is permittivity of free space, A is area of overlap, *d* is separation

When an insulator (or dielectric) other than a vacuum is used, the equation used is:

$$C = \frac{\varepsilon A}{d}$$ where $$\varepsilon = \varepsilon_r \varepsilon_0$$ and ε_r is **relative** permittivity.

ε is the permittivity for the insulator.

Material	ε_r
vacuum	1 (by definition)
air	1.0006
perspex	3.3
paper	4.0
mica	7.0
barium titanate	1200

The permittivity of an insulator in a capacitor is 6.195×10^{-11} Fm-1.

What material is between the plates?

$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{Fm}^{-1}$

Mica

0:05:00

Now complete questions 4, 5 and 6 in section 22.3

Extension: the Millikan oil drop questions on the same page

4 a $C \propto \frac{1}{d}$

$C = \frac{8.0}{2}$ [1]

$C = 4.0\,\text{pF}$ [1]

b $C \propto \frac{A}{d}$

Both A and d change by the same factor, so the ratio is the same. [1]

$C = 8.0\,\text{pF}$ [1]

5 $C = \frac{\varepsilon_0 \varepsilon_r A}{d} = \frac{8.85 \times 10^{-12} \times 4.0 \times \pi \times 0.10^2}{1.2 \times 10^{-3}}$ [1]

$C = 9.268 \times 10^{-10}\ \text{F}$ [1]

$Q = VC = 6.0 \times 9.268 \times 10^{-10}$ [1]

$Q = 5.56 \times 10^{-9}\ \text{C} \approx 5.6\ \text{nC}$ [1]

6 $mg = EQ = \frac{VQ}{d}$ [1]

$V = \frac{mgd}{Q} = \frac{2.5 \times 10^{-15} \times 9.81 \times 1.2 \times 10^{-2}}{2 \times 1.6 \times 10^{-19}}$ [2]

$V = 920\,\text{V}$ [1]

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Oct 16-21:59

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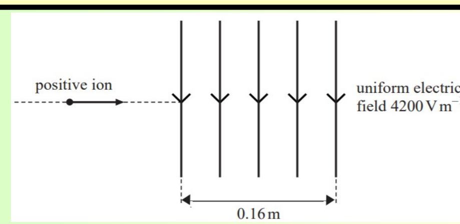
PLENARY:

An ion carrying a charge of $+4.8 \times 10^{-19}$C travels horizontally at a speed of $8.0 \times 10^{5}\,\mathrm{m\,s^{-1}}$. It enters a uniform vertical electric field of strength 4200 V $\mathrm{m^{-1}}$, which is directed downwards and acts over a horizontal distance of 0.16m.
Which one of the following statements is **not** correct?



A The ion passes through the field in 2.0×10^{-7}s.
B The force on the ion acts vertically downwards at all points in the field.
C The magnitude of the force exerted on the ion by the field is 1.6×10^{-9} N.
D The horizontal component of the velocity of the ion is unaffected by the electric field.

C: $F = EQ = 2.016 \times 10^{-15}$

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Aug 24-16:38